Space Weather Technical Forecast

Issued on Thursday, 16 May 2024 at 00:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of further X-class flares, mainly from new region on east limb with very active AR3664 moving further onto the far-side. S1 Minor Solar Radiation Storm easing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with two X-class flares observed. The largest, X3.4 at 15/0837 UTC was from AR3664 which continued to produce observable activity from over the southwest limb, but is now seeing its associated magnetic looping becoming increasingly obscured, limiting the potential for further flares to be observed. A further X2.9 was also observed peaking at 15/1438 UTC, from the southeast limb. The region associated with this is yet to become visible, but some notable looping is also evident on this limb. There are currently thirteen sunspot regions on the visible disc, however these are all relatively small, simple, and stable with only limited growth observed. The largest of these was AR3676 in the southeast, which showed some growth within its intermediate spots.

CMEs were observed with the X-flares, however these are not Earth-directed. A filament eruption was also observed around 15/0950 UTC from the northeast disc, however this has been assessed as likely missing Earth, passing north and behind.

Solar Wind / Geomagnetic Activity: A weak CME glance arrived at L1 at 15/1814 UTC, likely from the M6.6 flare of AR3664 on 13 May. No notable speed change was observed by ACE, with the elevated winds easing through the period to be slightly elevated, from 550 km/s to below 450km/s. However density rose from below average to around average values or just above. Interplanetary Magnetic Field (IMF), Bt, was initially weak, below 5nT, but exhibited a small increase to 7-8 nT at 15/1814 UTC. The north-south component remained weak however, and mainly in a negative direction, with minimum -6nT. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10 MeV) by GOES-18 has been at S1 Minor Radiation Storm level throughout. Observed proton flux has seen only a slight and erratic decline with peak values 31 pfu at 15/0225 UTC, easing to 18pfu at time of issue. High energy electron flux (greater than 2MeV) observed by GOES16 was Moderate to High, peaking 1500 pfu at 15/1840 UTC before dropping to background, likely due to the glancing CME arrival. The associated 24-hour fluence was below the Active threshold but on a rising trend, with an observed fluence at 15/2100 UTC of 6.74e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is now expected, with a slight chance of further X-class flares. These mainly from the new region that is expected to rotate onto the southeast limb which produced the X2.9 on 15 May. However, there is perhaps a very slight chance of further flares being observed from AR3664 during the first few hours. The regions currently on the visible disc are smaller and simpler, with isolated M-flares possible from these.

Solar Wind / Geomagnetic Activity: There is now one CME that may bring glancing influences, from the filament eruption on the north-east disc on 14 May. This is forecast to arrive either late

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day 2 or early day 3 (17-18 May), but low confidence. Otherwise, solar winds are currently slightly elevated with a very slightly enhanced magnetic field, due to the glancing CME from M6.6 of AR3664 on 13 May, however this is forecast to ease with no other notable enhancement currently expected. Mainly Quiet activity is expected with Unsettled intervals, but with the potential for Unsettled to Active spell with a slight chance of G1 Minor Storm intervals from the CME glance.

Energetic Particles / Solar Radiation: GOES-18 proton flux is expected to continue easing likely falling below the S1 level day 1-2 (16-17 May), but still with the potential for enhancements from any further significant flares from AR3664, as the protons can still be directed towards Earth along the Parker Spiral. This potential gradually declining as the sunspot moves further onto the far-side. High energy electron flux is forecast to also rise as solar winds ease, bringing a chance of Active fluence by day 2 (17 May), however this is low confidence.

Figure 1a: ACE SWEPAM showing weak arrival of 13 May M6.6 flare CME

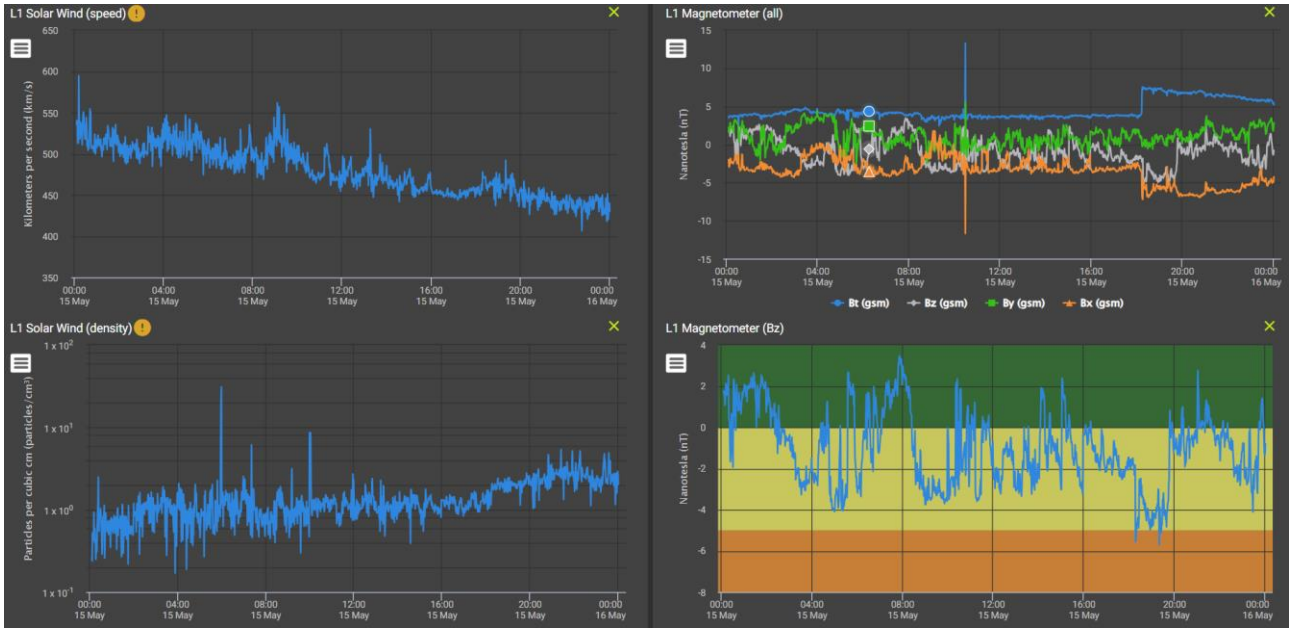

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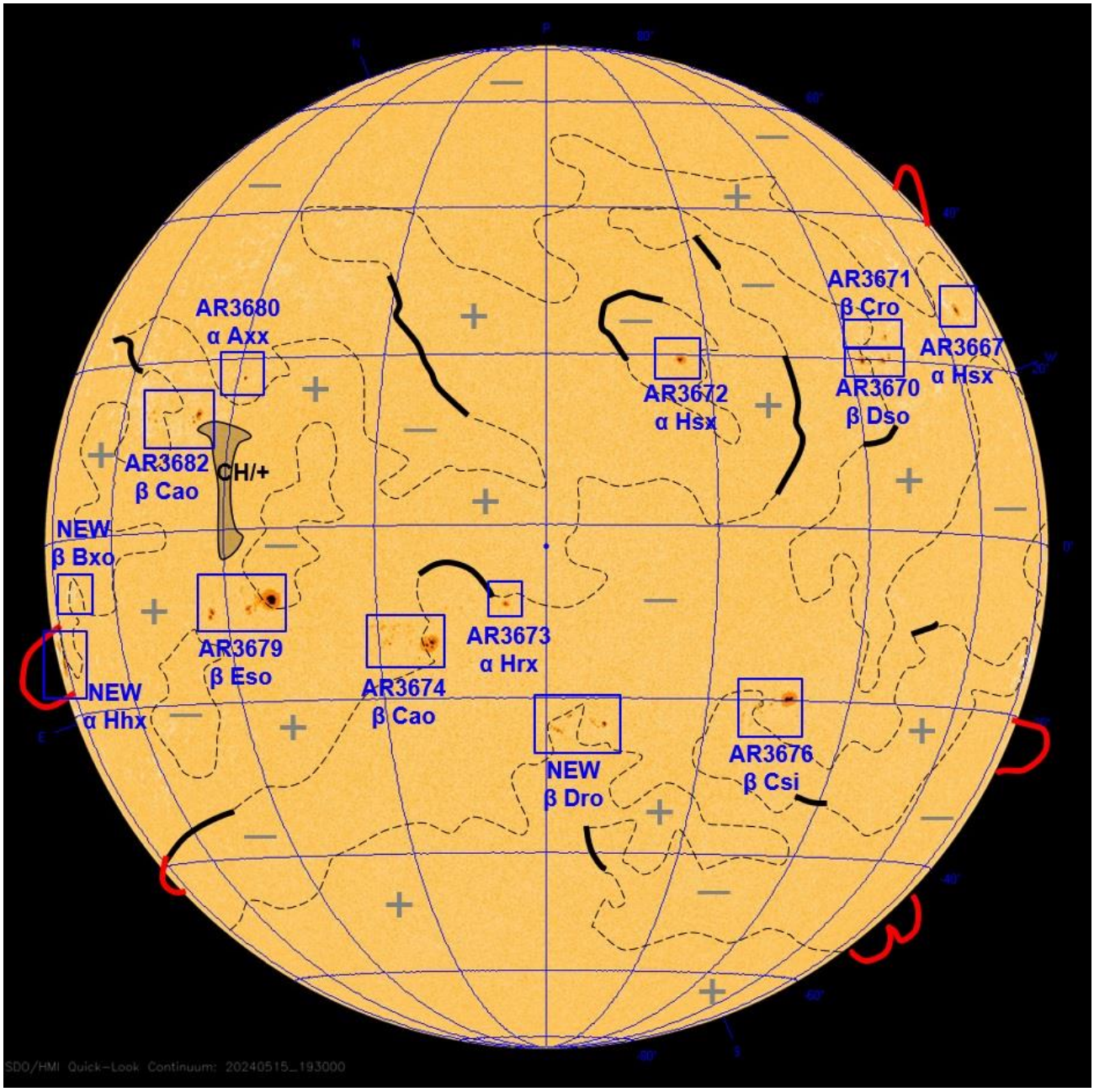
Figure 1b. Solar Analysis Valid 15/2000 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CMEs from AR3664 have now passed with any further ones expected to miss. However there is one other CME potentially arriving at Earth, later on day 2 or day 3 (17-18 May). This is was due to a filament eruption from the northeast disc on 14 May. While largely passing north and behind Earth, glancing interactions are possible late on day 3 or early day 4 (17-18 May).

Otherwise solar winds are currently seeing very weak glancing CME influence from the passing 13 May M6.6 flare CME. These winds are expected to be gradually easing towards background speeds, with no notable coronal hole enhancement expected. Activity is expected to be mainly Quiet with Unsettled intervals, but with spells of Unsettled to Active possible from any CME glance, along with a slight chance of G1 Minor storms, most likely early day 1 (16 May) or later day 2 into day 3 (17-18 May).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/1526	Nil	Filament	NE	685 km/s	17/2200 UTC +/- 10 hrs	Low confidence. Glancing impact.

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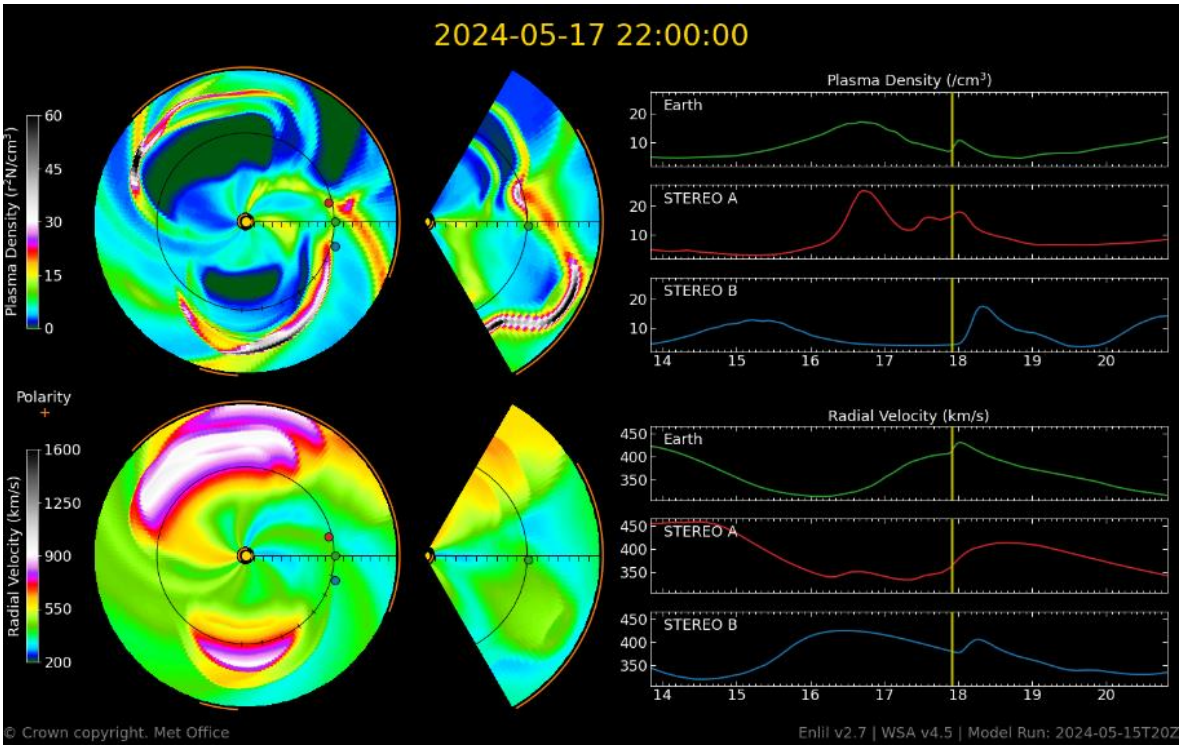
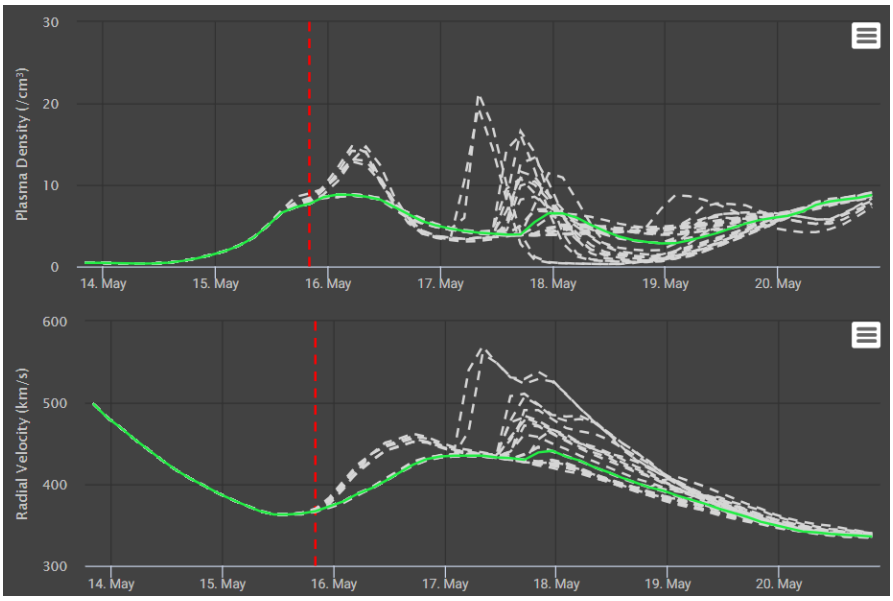
Figure 2: Enlil and ensemble showing slight glance on 16/17 May





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Radio Blackouts - X-Ray Flares:

Low to Moderate activity is expected, but with a chance of High activity continuing, largely dependent upon a new region rotating onto the southeast disc. This was the source of an X2.9 flare on 15 May, but is currently impossible to analyse, likely rotating onto the visible disc through the coming 24 hours.

Recent activity has been dominated by the very active region AR3664, however this sunspot group has now moved onto the far-side with any subsequent activity increasingly unlikely to be visible from the Earth-side, perhaps still just possible during the first few hours of day 1 (15 May).

There are currently thirteen visible regions on the disc, however these are generally small and relatively simple groups that are unlikely to produce more than isolated M-flares. The largest of these is AR3679 in the southwest disc, and this has shown some slow growth, but remains a simple bipolar group.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	50	40
Very Active	R3 to R5 X Class	Yes	25	20	10	10

Figure 3a: GOES-16/18 X-ray Flux

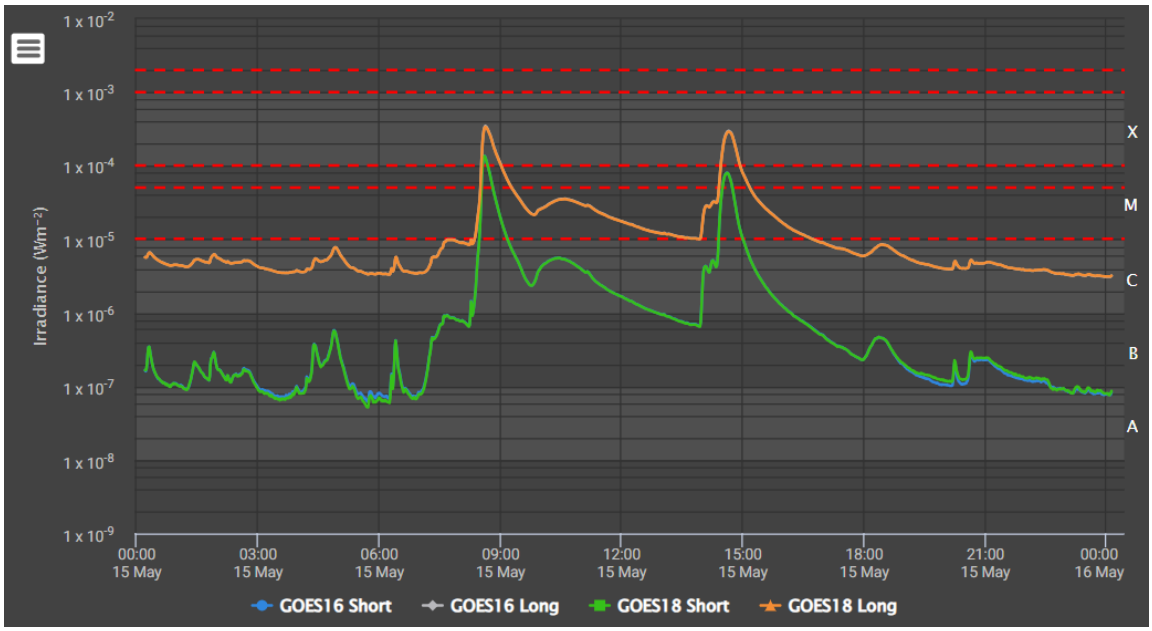

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Figure 3b: SDO aia-94 showing observed X-flares (X2.9 left, X3.4 right)

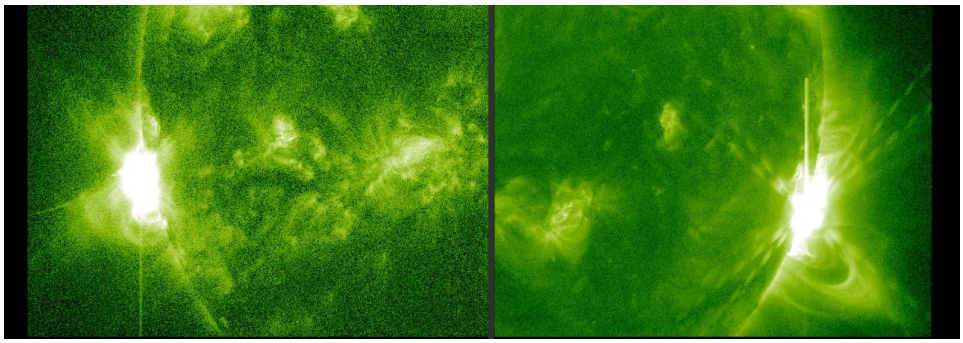


Figure 3c: Looping still evident over SW limb in SDO imagery

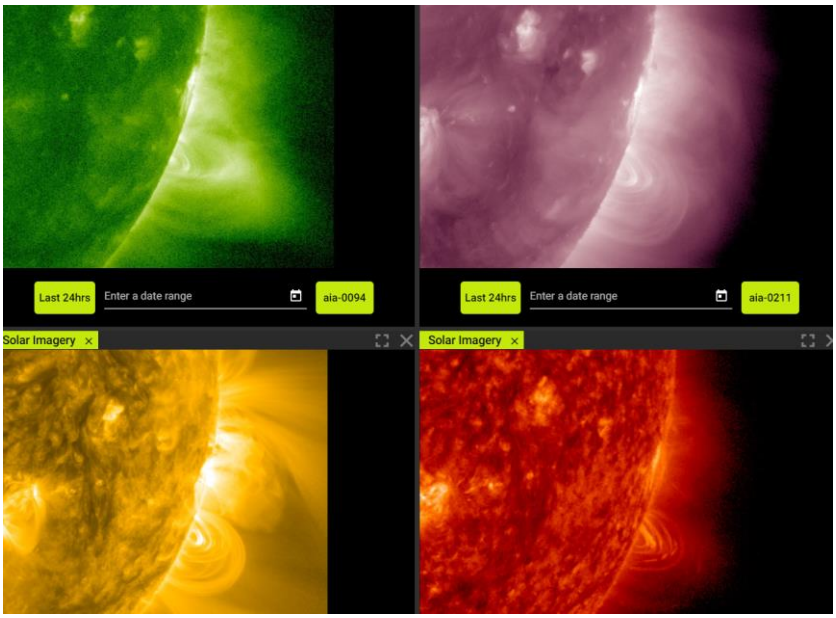
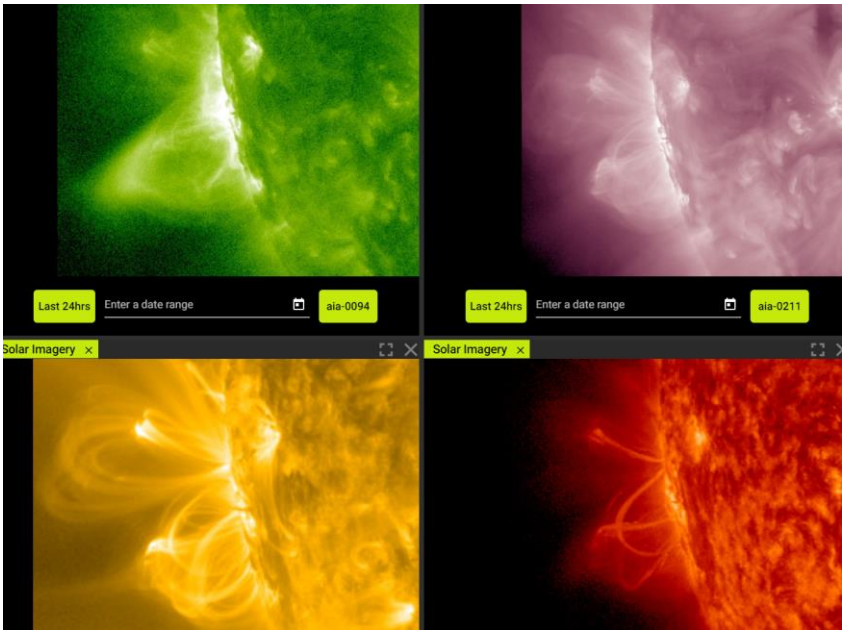


Figure 3d: Looping evident over SE limb in SDO imagery



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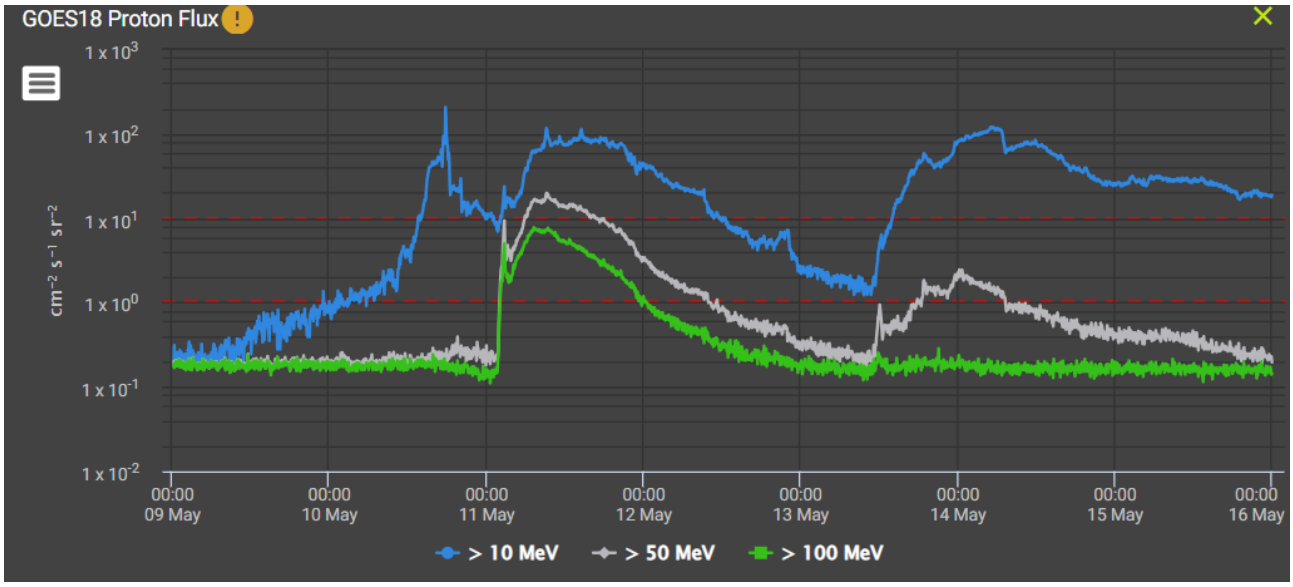
Solar Radiation Storms - (High Energy Protons):

S1 Minor Radiation Storm conditions will persist at the start of the period. This was due to the M6.6 flare of AR3664 on the southwest limb on 13 May with some contribution also possible from the flaring from this region through 14-15 May, with at least four X-flares occurring.

Proton flux is expected to gradually ease, likely falling below minor storm levels through days 1-2 (16-17 May), although further enhancements cannot be ruled out if any large flares occur from AR3664 from over the southwest limb, as it remains possible that any subsequent protons can be directed towards Earth through the Parker Spiral. While there are a number of small sunspot regions of the Earth-facing disc none of these are currently considered candidates for proton rich flares, with the potential for proton storms decreasing as AR3664 moves further onto the far-side.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	Yes	100	30	20	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: >10 MeV, >50 MeV and >100 MeV over the last seven days. Ongoing S1 Storm.



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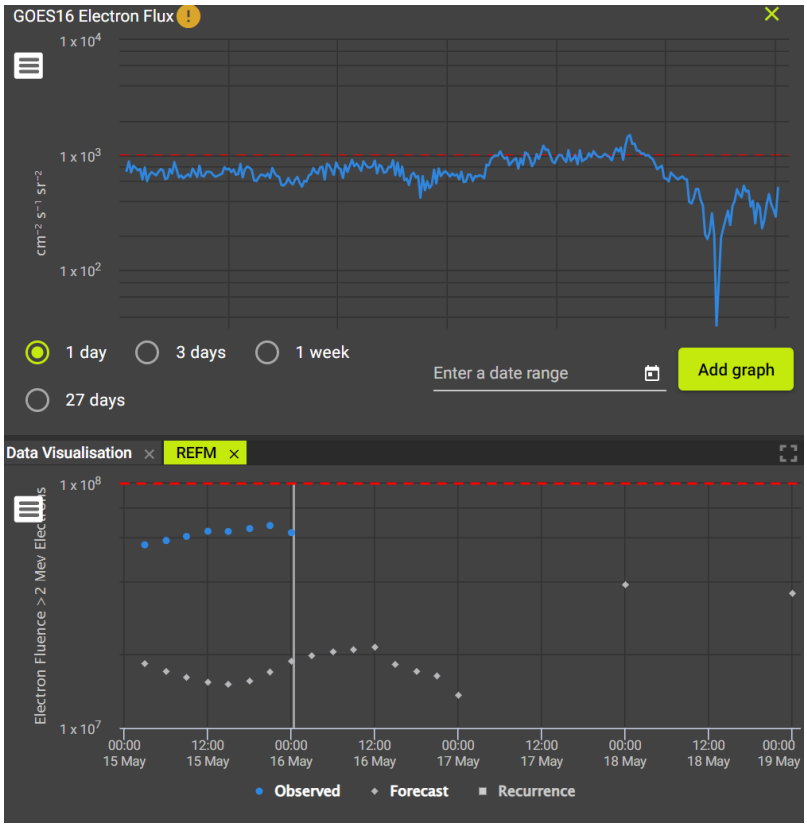
High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16 has been at mainly Moderate to High levels, but briefly dropped out from a weak CME glance late on 15 May, before rising again. An increasing trend is most likely to resume, however the potential for this to reach persistently High flux is now slightly reduced in confidence, despite lower orbits having been charged by the CME arrivals over the previous days. This is further reduced in confidence due to another potential weak glancing CME later on day 2 or day 3 (17-18 May), with may again reduce the observed flux.

The associated 24 hour fluence is expected to see a general rising trend, perhaps approaching the Active threshold, with a chance of exceeding this by day 2 (17 May). However, MOSWOC REFM now suggests peak fluence is likely to remain below this level, adding to the uncertainty of reaching Active.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	50	50	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES-16 Electron flux and fluence with REFM. Drop-out visible from CME arrival



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